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BS NA EN 1996-3 (2006) (English): UK National Annex to Eurocode 6. Design of masonry structures. Simplified calculation methods for unreinforced masonry structures

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NATIONAL ANNEX

UK National Annex to Eurocode 6: Design of masonry structures –

Part 3: Simplified calculation methods for unreinforced masonry structures

ICS 91.010.30; 91.080.30

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National Annex (informative) to BS EN 1996-3:2006, Eurocode 6: Design of masonry structures – Part 3: Simplified calculation methods for unreinforced masonry structures

Introduction

This National Annex has been prepared by BSI Subcommittee B/525/6, *Use of masonry*. It is to be used in conjunction with BS EN 1996-3:2006.

NA.1 Scope

This National Annex gives:

a) decisions for the Nationally Determined Parameters for the following subclauses of BS EN 1996-3:2006:

- **2.3**(2) P verification by the partial factor method;
- **4.1**(P) verification of the overall stability of a building;
- **4.2.1.1**(1) P general conditions;
- **4.2.2.3**(1) capacity reduction factor;
- **D.1**(1) characteristic compressive strength;
- **D.2**(1) characteristic flexural strength;
- **D.3**(1) characteristic initial shear strength.

b) decisions on the use of informative Annexes A and C;

c) references to non-contradictory complementary information to assist the user to apply BS EN 1996-3:6 (see **NA.4**).

NA.2 Nationally Determined Parameters

NA.2.1 Verification by partial factor method: values of γ_M [see BS EN 1996-3:2006, **2.3**(2)P]

The values for γ_M for the ultimate state limit are given in Table NA.1.

The recommended value for γ_M for all of the materials listed in Table NA.1 is 1,0.

Table NA.1 **Values of γ_M for ultimate limit state**

Class of execution control:	γ_M	
	1 [A]	**2** [A]
Material		
Masonry		
When in a state of direct or flexural compression		
Unreinforced masonry made with:		
units of category I	2,3 [B]	2,7 [B]
units of category II	2,6 [B]	3,0 [B]
When in a state of flexural tension		
units of category I and II	2,3 [B]	2,7 [B]
When in a state of shear		
Unreinforced masonry made with:		
units of category I and II	2.5 [B]	2.5 [B]
Steel and other components		
Ancillary components – wall ties	3,5 [B]	3,5 [B]
Ancillary components – straps	1,5 [C]	1,5 [C]
Lintels in accordance with BS EN 845-2	See NA to BS EN 845-2	See NA to BS EN 845-2

[A] Class 1 of execution control should be assumed whenever the work is carried out following the recommendations for workmanship in BS EN 1996-2, including appropriate supervision and inspection, and in addition:

a) the specification, supervision and control ensure that the construction is compatible with the use of the appropriate partial safety factors given in BS EN 1996-1-1;

b) the mortar conforms to BS EN 998-2, if it is factory made mortar, or if it is site mixed mortar, preliminary compression strength tests carried out on the mortar to be used, in accordance with BS EN 1015-2 and BS EN 1015-11, indicate conformity to the strength requirements given in BS EN 1996-1-1 and regular testing of the mortar used on site, in accordance with BS EN 1015-2 and BS EN 1015-11, shows that the strength requirements of BS EN 1996-1-1 are being maintained.

Class 2 of execution control should be assumed whenever the work is carried out following the recommendations for workmanship in BS EN 1996-2, including appropriate supervision.

[B] When considering the effects of misuse or accident these values may be halved.

[C] For horizontal restraint straps, unless otherwise specified, the declared ultimate load capacity depends on there being a design compressive stress in the masonry of at least 0,4 N/mm^2. When a lower stress due to design loads may be acting, for example when autoclaved aerated concrete or lightweight aggregate concrete masonry is used, the manufacturer's advice should be sought and a partial safety factor of 3 should be used.

NA.2.2 Verification of the overall stability of a building [see BS EN 1996-3:2006, **4.1**(P)]

The verification may be carried out in accordance with BS EN 1996-1-1:2005, **5.4**(1). Alternatively, within the scope of this document, the simplified method given in BS 8103-2 may be used.

NA.2.3 General conditions [see BS EN 1996-3:2006, **4.2.1.1**(1)P]

The numerical value ascribed to the symbol h_m is 12 m (Class 3).

NA.2.4 Capacity reduction factor
[see BS EN 1996-3:2006, **4.2.2.3**(1)]

The value of n_{tmin}, the minimum number of wall ties or connectors per m2 of cavity wall, is 2.5.

NA.3 Decisions on the status of the informative annexes and values for the normative Annex D

NA.3.1 Decisions on the status of the informative annexes

BS EN 1996-3:2006 informative Annexes A and C are not recommended for use as they both give extremely conservative results which are not economic compared with other available methods of design.

NA.3.2 Values for the normative Annex D

NA.3.2.1 Characteristic compressive strength determined with a simplified method[see BS EN 1996-3:2006, **D.1**(1)]

The characteristic compressive strength, $f_{k,s}$, should be taken from Table NA.2.

Table NA.2 **Values for $f_{k,s}$**

f_b N/mm²	General purpose mortar				Thin layer mortar	Light weight mortar		
	M2	M4	M6	M12		M2	M4	M6
Clay units group 1								
2	1.0	1.2	1.2	1.2	1.4	0.6	0.7	0.7
4	1.6	2.0	2.3	2.5	2.4	1.0	1.2	1.4
6	2.2	2.7	3.0	3.7	3.4	1.3	1.6	1.8
8	2.6	3.2	3.7	4.5	4.4	1.6	1.9	2.2
10	3.1	3.8	4.3	5.3	5.3	1.9	2.3	2.6
12	3.5	4.3	4.9	6.0	6.2	2.1	2.6	2.9
16	4.3	5.3	6.0	7.3	7.9	2.6	3.2	3.6
20	5.0	6.2	7.0	8.6	9.6	3.0	3.7	4.2
25	5.9	7.2	8.1	10.0	11.6	3.5	4.3	4.9
30	6.7	8.2	9.3	11.4	13.5	4.0	4.9	5.6
50	9.5	11.7	13.2	16.3	20.9	5.7	7.0	7.9
75	12.6	15.6	17.6	21.6	20.9	7.6	9.3	10.5

Table NA.2 **Values for $f_{k,s}$** (*continued*)

f_b N/mm²	General purpose mortar				Thin layer mortar	Light weight mortar		
	M2	M4	M6	M12		M2	M4	M6
Clay units group 2								
2	0.8	1.0	1.0	1.0	1.1	0.5	0.6	0.6
4	1.3	1.6	1.8	2.0	1.8	0.8	1.0	1.1
6	1.7	2.1	2.4	3.0	2.5	1.1	1.3	1.5
8	2.1	2.6	2.9	3.6	3.0	1.3	1.6	1.8
10	2.5	3.0	3.4	4.2	3.5	1.5	1.9	2.1
12	2.8	3.5	3.9	4.8	4.0	1.8	2.2	2.4
16	3.4	4.2	4.8	5.9	4.9	2.1	2.6	3.0
20	4.0	4.9	5.6	6.9	5.7	2.5	3.1	3.5
25	4.7	5.8	6.5	8.0	6.7	2.9	3.6	4.1
30	5.3	6.6	7.4	9.1	7.6	3.3	4.1	4.6
50	7.6	9.4	10.6	13.0	10.8	4.8	5.9	6.6
75	10.1	12.5	14.1	17.3	10.8	6.3	7.8	8.8
Calcium silicate units group 1								
2	1.0	1.2	1.2	1.2	1.4	–	–	–
4	1.6	2.0	2.3	2.5	2.6	–	–	–
6	2.2	2.7	3.0	3.7	3.7	–	–	–
8	2.6	3.2	3.7	4.5	4.7	–	–	–
10	3.1	3.8	4.3	5.3	5.7	–	–	–
12	3.5	4.3	4.9	6.0	6.6	–	–	–
16	4.3	5.3	6.0	7.3	8.4	–	–	–
20	5.0	6.2	7.0	8.6	10.2	–	–	–
25	5.9	7.2	8.1	10.0	12.3	–	–	–
30	6.7	8.2	9.3	11.4	14.4	–	–	–
50	9.5	11.7	13.2	16.3	22.2	–	–	–
Calcium silicate units group 2								
2	0.8	1.0	1.0	1.0	1.3	–	–	–
4	1.3	1.6	1.8	2.0	2.3	–	–	–
6	1.7	2.1	2.4	3.0	3.2	–	–	–
8	2.1	2.6	2.9	3.6	4.1	–	–	–
10	2.5	3.0	3.4	4.2	5.0	–	–	–
12	2.8	3.5	3.9	4.8	5.8	–	–	–
16	3.4	4.2	4.8	5.9	7.4	–	–	–
20	4.0	4.9	5.6	6.9	8.9	–	–	–
25	4.7	5.8	6.5	8.0	10.8	–	–	–
30	5.3	6.6	7.4	9.1	12.6	–	–	–
50	7.6	9.4	10.6	13.0	19.5	–	–	–

Table NA.2 Values for $f_{k,s}$ *(continued)*

f_b N/mm²	General purpose mortar				Thin layer mortar	Light weight mortar		
	M2	M4	M6	M12		M2	M4	M6
Aggregate concrete block units of group 1 and autoclaved aerated block units group 1								
2	1.1	1.4	1.4	1.4	1.4	0.9	1.1	1.1
4	1.8	2.2	2.5	2.7	2.6	1.5	1.8	2.0
6	2.4	2.9	3.3	4.1	3.7	1.9	2.4	2.7
8	2.9	3.6	4.0	5.0	4.7	2.4	2.9	3.3
10	3.4	4.2	4.7	5.8	5.7	2.8	3.4	3.9
12	3.9	4.7	5.4	6.6	6.6	3.2	3.9	4.4
16	4.7	5.8	6.6	8.1	8.4	3.9	4.8	5.4
20	5.5	6.8	7.7	9.4	10.2	4.5	5.6	6.3
25	6.4	7.9	9.0	11.0	12.3	5.3	6.5	7.3
30	7.3	9.0	10.2	12.5	14.4	6.0	7.4	8.3
50	10.5	12.9	14.6	17.9	22.2	8.6	10.5	11.9
Aggregate concrete block units group 2								
2	1.0	1.3	1.3	1.3	1.4	0.9	1.1	1.1
4	1.7	2.1	2.3	2.6	2.5	1.5	1.8	2.0
6	2.2	2.8	3.1	3.8	3.5	1.9	2.4	2.7
8	2.7	3.4	3.8	4.7	4.5	2.4	2.9	3.3
10	3.2	4.0	4.5	5.5	5.4	2.8	3.4	3.9
12	3.6	4.5	5.1	6.2	6.3	3.2	3.9	4.4
16	4.5	5.5	6.2	7.6	8.0	3.9	4.8	5.4
20	5.2	6.4	7.2	8.9	9.7	4.5	5.6	6.3
25	6.1	7.5	8.5	10.4	11.7	5.3	6.5	7.3
30	6.9	8.5	9.6	11.9	13.7	6.0	7.4	8.3
50	9.9	12.2	13.8	16.0	21.1	8.6	10.5	11.9

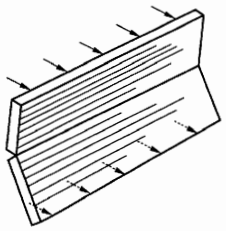
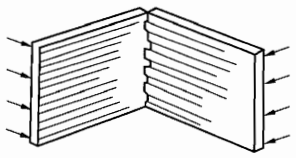
NA.3.2.2 Characteristic flexural strengths determined with a simplified method [see BS EN 1996-3:2006, **D.2**(1)]

The characteristic flexural strengths, $f_{xk1,s}$ and $f_{xk2,s}$, should be taken from Table NA.3.

Provided that thin layer mortars and lightweight mortars are M5, or stronger:

- for thin layer mortars use the values given for M12 mortar;
- for lightweight mortars use the values given for M2 mortar.

Table NA.3 **Characteristic flexural strength of masonry, $f_{xk1,s}$ and $f_{xk2,s}$ in N/mm²**

	Values of $f_{xk1,s}$ Plane of failure parallel to bed joints 			**Values of $f_{xk2,s}$** Plane of failure perpendicular to bed joints 		
Mortar strength class:	**M12**	**M6 and M4**	**M2**	**M12**	**M6 and M4**	**M 2**
Clay masonry units of groups 1 and 2 having a water absorption (see Note 1) of:						
less than 7%	0,7	0,5	0,4	2,0	1,5	1,2
between 7% and 12%	0,5	0,4	0,35	1,5	1,1	1,0
over 12%	0,4	0,3	0,25	1,1	0,9	0,8
Calcium silicate brick sized* masonry units		0,3	0,2		0,9	0,6
Aggregate concrete brick sized* masonry units		0,3	0,2		0,9	0,6
Aggregate concrete masonry units and manufactured stone of groups 1 and 2 and AAC masonry units used in walls of thickness up to 100 mm (see Note 2 and 3) of declared compressive strength:						
2,9		0,25	0,2		0,4	0,4
3,6					0,45	0,4
7,3					0,6	0,5
Aggregate concrete masonry units and manufactured stone of groups 1 and 2 and AAC masonry units used in walls of thickness of 250 mm or greater (see Note 2 and 3), of declared compressive strength:						
2,9		0,15	0,1		0,25	0,2
3,6					0,25	0,2
7,3					0,35	0,3
Aggregate concrete masonry units and manufactured stone of groups 1 and 2 and AAC masonry units used in walls of any thickness (see Note 2), of declared compressive strength:						
10,4		0,25	0,2		0,75	0.6
⩾17,5					0,9 (see Note 4)	0,7 (see Note 4)

NOTE 1 Tests to determine the water absorption of clay masonry units are to be conducted in accordance with BS EN 772-7.

NOTE 2 The thickness should be taken to be the thickness of the wall, for a single-leaf wall, or the thickness of the leaf, for a cavity wall.

NOTE 3 Linear interpolation may be used to obtain the values of f_{xk1} and f_{xk2} for:

a) wall thicknesses greater than 100 mm and less than 250 mm;

b) compressive strengths between 2,9 N/mm² and 7,3 N/mm² in a wall of given thickness.

NOTE 4 When used with flexural strength in the parallel direction, assume the orthogonal ratio $\mu = 0,3$.

* units not exceeding 337.5 mm × 225 mm × 112.5 mm

NA.3.2.3 Characteristic initial shear strength of masonry determined with a simplified method

[see BS EN 1996-3:2006, **D.3**(1)]

The characteristic initial shear strength, f_{vko}, should be taken from Table NA.4.

Table NA.4 **Values of the initial shear strength of masonry, f_{vko}**

Masonry units	**Strength class of general purpose mortar**	**f_{vko} (N /mm²)**		
		General purpose mortar	**Thin layer mortar (bed joint ⩽ 0,5 mm and ⩾ 3 mm)**	**Lightweight mortar**
Clay	M12	0,30	0,30	0,15
	M4 and M6	0,20		
	M2	0,10		
Calcium silicate	M12	0,20	0,40	0,15
	M4 and M6	0,15		
	M2	0,10		
Aggregate concrete, autoclaved aerated concrete, manufactured stone and dimensioned natural stone	M12	0,20	0,30	0,15
	M4 and M6	0,15		
	M2	0,10		

NA.4 References to non-contradictory complementary information

When considering both detailing and permissible deviations, the designer's attention is drawn to following non-contradictory and complementary information:

PD XXXX: 200Y, TITLE, [a standard comprising complementary and non-contradictory material taken from BS 5628-1, BS 5628-2 and BS 5628-3] [1)]

Morton J. *Designers' guide to EN 1996-1-1 Eurocode 6: Design of masonry structures – Common rules for reinforced and unreinforced masonry structures* [1)] London: Thomas Telford Ltd.

Manual for the design of plain masonry building structures to Eurocode 6 [1)] London: Institution of Structural Engineers

EUROCODE 6 HANDBOOK [1)] London: Department of Communities and Local Government

Eurocode for Masonry, BS EN 1996: *Guidance and Worked Examples* [1)] Surrey: British Masonry Society

[1)] In preparation.

Bibliography

BS 8103-2, *Structural design of low rise buildings – Part 2: Code of practice for masonry walls for housing*

BS EN 772-7, *Methods of test for masonry units – Part 7: Determination of water absorption of clay masonry damp proof course units by boiling in water*

BS EN 845-2, *Specification for ancillary components for masonry – Part 2: Lintels*

BS EN 998-2, *Specification for mortar for masonry – Part 2: Masonry mortar*

BS EN 1015-2, *Methods of test for mortar for masonry – Part 2: Bulk sampling of mortars and preparation of test mortars*

BS EN 1015-11, *Methods of test for mortar for masonry – Part 11: Determination of flexural and compressive strength of hardened mortar*

BS EN 1996-1-1, *Eurocode 6 – Design of masonry structures – Part 1-1: General rules for reinforced and unreinforced masonry structures*

BS EN 1996-2, *Eurocode 6 – Design of masonry structures – Part 2: Design considerations, selection of materials and execution of masonry*

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